ART. IV. — *Physical Geography.* By MARY SOMERVILLE. The Second American Edition from the New and Revised London Edition. Philadelphia : Lea & Blanchard. 12mo. pp. 485.

IT was once supposed that science could flourish only under the fostering care of princes, and that its theories and discoveries could be conveyed only from one learned body to another. The kind of knowledge fit for those engaged in the active business of life was believed to be limited to those facts which could be turned to account in the various trades and callings. The dyer, for instance, might be taught what combinations would produce the desired colors, the machinist somewhat of the qualities of the various metals, the navigator how to use the quadrant and to cull the logarithms necessary for the calculation of the latitude of his ship ; but to understand aright the principles of chemistry, metallurgy, astronomy, or any of the higher branches of mathematics, was for the special cultivators of science. The surface of the world, its natural and artificial productions, and their use and value, were to be studied by the many ; but the laws of the organization of the world, and of the movements of its elements, were to be understood by the few. Useful knowledge, — 'that which will pay,' — was all that the merchant, farmer, or artisan could acquire ; the exquisite pleasure of knowing, apart from every practical use of the knowledge, was the privilege of those only who devoted their lives to scientific pursuits.

Thus, civil and political geography has for a long time been taught, for it gives knowledge useful to every class and vocation. Every man should know the definition of cape, island, and continent, — should be made familiar with the various lines and curves delineated on the maps, — should be able to 'bound' states and empires, and learn by rote the rise and course of their principal rivers, the position of the chief towns and cities, their population and their productions. What more can the business man use than that knowledge found in the common school geography ? And is it not the sole aim of education to fit one for his station, to qualify him for a life of industry, usefulness, and money-making ? This is

unquestionably all that is needed in what is called a man's industrial position ; it is all that can be of service to him as the wisest of animals, — all that can avail in the production, preservation, and distribution of the good things which pertain to the body.

But utilitarian knowledge does not altogether satisfy the present generation. They have begun to recognize other relations to the earth than its fitness to supply their bodily wants ; to believe that this beautiful and wonderful world is to do more for them than to furnish a comfortable living. "When I walk abroad," said an illiterate man, "it seems to me as if God's hand had hold of every thing." This is the belief or sentiment which impels many to extend their inquiries beyond what is practically useful. The world has two sides to it ; God is on the one, man is on the other. On the one hand, is the Giver of every good gift ; on the other, those who are employed in collecting and appropriating the gifts ; there, the wisdom of God, here, the skill and craft and cunning of man ; there, a world radiant with loving-kindness, here, the battle fields and arenas of contention for wealth, reputation, and power. There are few indeed, so low in intellect, or so depressed in education, as to be content with that side of the world only which reflects themselves, their wants and their business, without bestowing passing glimpses at least on the divine side of the creation.

Physical Geography gives us the higher view of the earth we inhabit. It unfolds the laws of nature in the form and motion of the world, and in the action of its elements. In the language of our author, "political and arbitrary divisions are disregarded, and the sea and the land are considered with respect to those great features which have been stamped upon them by the hands of the Almighty." Physical Geography speaks of the changes "which have brought the rude mass to its present fair state, and of the myriads of beings that have appeared on this mortal stage, have fulfilled their destinies, and have been swept from existence to make way for new races, which, in their turn, have vanished from the scene, till the creation of man completed the glorious work." It relates, also, to the changes now taking place, — the conflicts of earth, ocean, and air, in the tempest and earthquake ; and to the gentler vicissitudes, the soft winds, the

ever returning tides of the ocean, and the almost unheeded undulations of the land. It treats of day and night, and summer and winter; of the rain and hail and snow; of the electric and magnetic currents; of the depths of ocean and the heights of mountains. It presents 'the life of the world,' the activity of the elements, and the nature of the materials of which it is composed. It is indeed a vast theme, and one full of the most intense interest. To do it justice requires a knowledge of the leading truths of every branch of science, and a talent so to combine and arrange the discoveries of the mineralogist and geologist, of the astronomer and natural philosopher, as to present a system of general physics. It is an attempt to apply the abstractions of science so that they may explain the world's phenomena; to withdraw them from their illustration by artificial experiments, and to subject them to a new test, — their application to the vicissitudes of the elements. It is the aim of physical geography thus to popularize science, — to bring it within the grasp of the common mind.

The appearance of a second American edition, from the new and revised London edition of Mrs. Somerville's book, proves that there is a demand for works of this character. In fact, with the exception of the annual reports of scientific associations, and of the periodicals of science, all the late scientific works are of a popular character. "The Principles of Zoölogy," "The Connection of the Physical Sciences," "The Poetry of Science," Johnston's "Physical Atlas," "Earth and Man," "Lake Superior," and numerous other books of a similar character, give evidence of a new direction of the scientific talent of the day. Does not the success of these works prove that science has made such progress that the learned can impart their knowledge to the people, and that the people, on the other hand, are prepared to receive the instruction? Is not this an encouraging feature of the times, reflecting much honor on those who teach, and those who are capable of receiving the lesson?

Still, there are those who doubt whether science can be transferred otherwise than from one learned body to another. It is supposed that such books as Mrs. Somerville's are read as a novel or romance is read, for mere amusement, — because they are accounts of the beautiful and wonderful things

of the world, — without any attempt being made by their readers to comprehend the principles of physics, which their explanations involve; that though there may be raised up a host of sciolists and smatterers in science, thorough learning, — and none other is useful, — comes from the devotion of a lifetime to one subject; and that science still has conflicting theories which task even the minds devoted to its cultivation.

All this may be true. We admit that hard and dry sciences do not become soft and succulent when administered in small pieces. The poor do not become strong when fed with the crumbs which fall from the rich man's table. The food, however, which nourishes the rich, will also strengthen the poor. To drop the metaphor, the active men of the community cannot devote their time exclusively to scientific investigations, nor can they even comprehend the results of the investigations of others, unless these results are distinctly evolved and presented clear of the process by which they were obtained. It is for the chemist to work in the laboratory, to be an expert in all the arts of manipulation; but if he, by the crucible or retort, discovers truth, this truth can be expressed simply and intelligibly. It is for the mathematician to make calculations, to use his peculiar processes of thought, and if he obtains thereby some new law or general truth, his idea can be expressed in language which any tolerably well educated man can understand. A truth which clings to the crucible, or remains wrapped up in mathematical formulas, is a truth of process, of value only to the expert himself. There is much, indeed, which baffles the wisdom of those who devote their lives to the investigations of the laws of nature. The greater part of these difficulties, however, are processes merely, — refinements of logic and calculation supposed to be necessary for the attainment of the truth. These, as matters entirely distinct from the truth itself, will ever remain the exclusive property of those who are professionally scientific. But truth actually obtained is the property of the active minds about them. Indeed, the very test of the value of a theory is its directness, its simplicity, and the readiness with which it may be applied. The separation of scientific *truth* from the scientific *processes*, the assignment of the one to the class who teach, and the communication of the other to those engaged in the active duties of life, is in itself a desirable work;

and it is this end which the present popular treatises are designed to effect.

It is a prevalent idea, "that the physical sciences involve the application of mathematics, and sometimes of its most subtile and intricate departments." We may admit all this; but it is a mistake to suppose that great mathematical power is necessary to the comprehension of a theory which it needed great mathematical power to establish. The mathematician, by his peculiar skill, is to extend and verify; and that which is extended or verified, is, or ought to be, some truth, principle, or theory, which can live and do good in the world when it is withdrawn from the process of calculation. For instance, the extension of attraction, from the falling apple to the rolling sphere, or the theory of universal gravitation, "took its rise from a fortunate conjecture." "It was the inspiration of a bold and self-relying mind." Sir Isaac Newton's subsequent process was to verify it by calculation; and thus verified, it was cleansed of its mathematics, to give it its finish and value to the world. Who doubts its truth, or fails to comprehend the theory, *because* he cannot follow its author in the profound calculation by which it is supposed to be established as the law of the systems of worlds?

There is another supposed impediment to the more general diffusion of scientific truth, — an unwillingness or incapacity of the many to retain in their minds the vast array of facts which modern science has accumulated. They who devote themselves to science, it is believed, may remember all that is necessary, for their long-continued study has deepened the association of fact with fact; or, if oblivious, their well-filled libraries will supply the required knowledge. They are supposed to have in their minds, or to know at once where to find, all that is necessary for their investigations. The laity, on the other hand, will not burden their memories with facts, or even with the technical words of science, or be at the trouble to refer to the books for the exact understanding of words and things, which is essential to the prosecution of physical inquiry.

Science, however, is not a knowledge of *facts*, but a knowledge of *principles* which stand in the place of facts. In other words, it is the work of science to take from facts their individuality, and by their classification and arrangement under certain laws, to transform them into principles. There

is much meaning in the words of the mystic, Jacob Behmen: "When," says he, "I take up a stone or a clod of earth, and look upon it, then I see that which is above and that which is below; only in each thing one property happeneth to be chiefest and manifest, according to which it is named; all other properties are jointly therein, only in distinct degrees and centres, and yet all the degrees and centres are but one only centre; there is one only root whence all things proceed." So, when we examine a fact in science, we see 'that which is above and that which is below it;' it has a name because some one attribute is the most manifest; but it carries us to the root or centre from which, radiating in every direction, are numerous kindred facts, which, thus united, classified, and associated one with the other, can never be forgotten. Science does not therefore burden the memory, but lightens it of its load; it destroys isolated phenomena by establishing the close and simple relations of one thing with another. It annihilates facts by stripping them of their distinctive character, by their resolution into principles. The greater the advance in science, the less there is to remember. To the ignorant only, and in direct proportion to their ignorance, is the world made up of isolated and discordant things. In the language of Mrs. Somerville, "Nature has not wrought after an indefinite number of types and models, but on the contrary, her fundamental forms are few, and derived from the action of definite constructive forces on a primary base." It is the office of science to present this primary base, and to trace out upon it the effect of the few distinct and central forces, which, in admirable simplicity of action, present to us the organization of the world and the changes of the elements of which it is composed.

We will illustrate this idea by examples. Mrs. Somerville, speaking of submarine phenomena, says, —

"The pressure at the great depths is enormous. In the Arctic Ocean, where the specific gravity of the water is lessened, on account of the greater proportion of fresh water produced by the melting of the ice, the pressure at the depth of a mile and a quarter is 2809 pounds on a square inch of surface; this was confirmed by Captain Scoresby, who says, in his 'Arctic Voyages,' that the wood of a boat suddenly dragged to a great depth by a whale was found, when drawn up, so saturated with water forced into its pores, that it sank in water like a stone for a year afterwards." p. 190.

Water may fall from a great height, and by this great descent acquire the force to enter the pores of the wood. It is said that the power of gravitation is accumulative in the falling body, and that its pressure or force of fall consequently increases with the time of the fall. Be this as it may, and however we may account for the fact, it is demonstrable by experiment and measurement, that pressure, weight, tendency to approach the centre, the force of descent, or whatever else it may be called, is in direct proportion to the degree of the descent. If water enters the pores of wood sunk to an immense depth, it enters with a force proportioned to the depth. On the same principle, water enters the leaky ship, or issues from the reservoir into the open air, with a force in direct proportion to the distance of the entrance or exit from the surface of the fluid. This force of descent can be measured, and will be found sufficient to elevate an equal quantity of water to the height from which it falls, or to elevate a smaller quantity, — for instance, by the hydraulic ram, — to a much greater height. However various the diameter of pipes connected with one fountain, the water stands at the same level in all, the force of elevation being equal to the force of descent, and neither more nor less of the fluid can rise than that quantity which falls. If we weigh a body, — a piece of lead for instance, — in water, it loses weight equal to water of its own bulk; for by its descent, it must needs elevate so much of the surrounding medium. A body of greater density sinks when immersed, but its force of fall is diminished to the degree necessary for the rise of an equal body of water; it floats when of less density, for its fall cannot raise its own bulk of the medium. The wave of the ocean runs upon the beach with a force dependent on the height of the billow which falls. Even the great globe itself, if it fall toward the centre of revolution, narrowing its orbit, moves in revolution with an acceleration proportioned to its approach to the centre. Perhaps we have mingled together phenomena usually united by other principles. It matters not. We seek to show that vast range of facts, running from the minute to the grand, from the saturation of the pores of wood sunk in the depths of the ocean to the march of the rolling spheres, that may be united under one principle; so that when a fact is presented for examination, we see "that which is below

and that which is above it." We would take as a motto to a work on physical geography the remark of Coleridge: "How great a thing is the possession of any one simple truth,— how mean a thing is a mere fact, except as seen in the light of some comprehensive truth!"

We meet with many striking illustrations of the value of principles in Mrs. Somerville's book.

"The tendency of the land to assume a peninsular form is very remarkable, and it is still more so that almost all the peninsulas tend to the south — circumstances that depend on some unknown cause which seems to have acted very extensively. The continents of South America, Africa, and Greenland, are peninsulas on a gigantic scale, all tending to the south; the Asiatic peninsula of India, the Indo-Chinese peninsula, those of Corea, Kamtchatka, of Florida, California, and Aliaska, in North America, as well as the European peninsulas of Norway and Sweden, Spain and Portugal, Italy and Greece, take the same direction. All the latter have a rounded form except Italy, whereas most of the others terminate sharply, especially the continents of South America and Africa, India, and Greenland, which have the pointed form of wedges; while some are long and narrow, as California, Aliaska, and Malacca. Many of the peninsulas have an island or group of islands at their extremity, as South America, which terminates with the group of Tierra del Fuego; India has Ceylon; Malacca has Sumatra and Banca; the southern extremity of New Holland ends in Van Dieman's Land; a chain of islands run from the end of the peninsula of Aliaska; Greenland has a group of islands at its extremity; and Sicily lies close to the termination of Italy. It has been observed, as another peculiarity in the structure of peninsulas, that they generally terminate boldly, in bluffs, promontories, or mountains, which are often the last portions of the continental chains. South America terminates in Cape Horn, a high promontory, which is the visible termination of the Andes; Africa with the Cape of Good Hope; India with Cape Comorin, the last of the Ghauts; New Holland ends with Southeast Cape in Van Dieman's Land; and Greenland's farthest point is the elevated bluff of Cape Farewell." p. 39.

"Notwithstanding the various circumstances of their elevation, there is everywhere a certain regularity of form in mountain masses, however unsymmetrical they may appear at first; and rocks of the same kind have identical characters in every quarter of the globe. Plants and animals vary with climate, but a granite mountain has the same peculiarities in the southern as in the northern hemisphere — at the equator as near the poles. Single

mountains, insulated on plains, are rare, except where they are volcanic ; they generally appear in groups intersected by valleys in every direction, and more frequently in extensive chains symmetrically arranged in a series of parallel ridges, separated by narrow longitudinal valleys, the highest and most rugged of which occupy the centre : when the chain is broad and of the first order in point of magnitude, peak after peak arises in endless succession. The lateral ridges and valleys are constantly of less elevation, and are less bold, in proportion to their distance from the central mass, till at last the most remote ridges sink down into gentle undulations. p. 41.

" The determination of the contemporaneous upheaval of parallel mountain-chains, by a comparison of the ages of the inclined and horizontal strata resting on them, is one of the highest steps of generalization which has been attempted by geologists. It was first observed by the miners of the Freyburg school, and established as a law by Werner, that veins of the same nature in mines occur in parallel fissures opened at the same time, and probably filled with metal, also simultaneously, at a subsequent period ; and that fissures differing in direction differ also in age. As these veins and fissures are rents through the solid strata, often of unfathomable depth and immense length, there is the strongest analogy between them and those enormous fissures in the solid mass of the globe through which the mountain-chains have been heaved up. Were the analogy perfect, it ought to follow that parallel mountain-chains have been raised simultaneously, that is, by forces acting during the same geological periods. By a careful examination of the relative ages of the strata resting on the flanks of many of the mountain systems, M. Elie de Beaumont has shown, if not proved, that all strata elevated simultaneously assume a parallel direction, or, that parallel strata are contemporaneous." p. 43.

" The geological outline of the United States, the Canadas, and all the country of the Polar Ocean, though highly interesting in itself, becomes infinitely more so when viewed in connection with that of northern and middle Europe. A remarkable analogy exists in the structure of the land on each side of the North Atlantic basin." p. 132.

" In all the more northern countries that have been mentioned, so very distant from one another, the general range of the rocks is from northeast to southwest ; and in northern Europe, the British isles, and North America, great lakes are formed along the junction of the strata, the whole analogy affording a proof of the wide diffusion of the same geological conditions in the northern regions at a very remote period." p. 133.

"The magnetism of the earth is presumed to be owing to electrical currents circulating through its surface in a direction at right angles to the magnetic meridians. Mr Fox, so well known in the scientific world, has long since shown, from observations in the Cornish mines, that such currents do flow through all metallic veins. Now, as the different substances of which the earth is composed are in different states of electro-magnetism, and are often interrupted by non-conducting rocks, the electric currents, being stopped in their course, act chemically on all the liquids and substances they meet with. Hence, Mr. Fox has come to the conclusion that not only the nature of the deposits must have been determined by their relative electrical conditions, but that the direction of the metallic veins themselves must have been influenced by the direction of the magnetic meridians; and, in fact, almost all the metallic deposits in the world are in parallel veins or fissures tending from east to west, or from northeast to southwest. Veins at right angles to these are generally non-metalliferous, and, if they do contain metallic ores, they are of a different kind." pp. 170, 171.

"There is strong presumptive evidence of the influence of the electric and magnetic currents on the formation and direction of the mountain masses and mineral veins; but their slow persevering action on the ultimate atoms of matter has been placed beyond doubt by the formation of rubies and other gems, as well as various other mineral substances, by voltaic electricity." p. 296.

"M. Necker de Saussure has traced a marked coincidence between the prevailing direction of the stratified masses of the mountain chains and that of the curves of equal magnetic intensity. The coincidence is perfect in the Ural chain, for there the lines of force tend north and south; and they do not deviate much from the stratification in the great plains of European Russia. There is every reason to believe that a coincidence takes place in the Scandinavian mountains, for a line of equal magnetic intensity passes parallel to the Norwegian coast. In Scotland, a line almost coincides with the Grampians; and as it becomes less northerly before reaching Portugal and Spain, it is there also in singular coincidence with the sierras on the table-land; the Pyrenees, however, form an exception to the law. A magnetic line follows the break of the chain of the Alps with great precision. The intersection of two upheavals makes these mountains alter their direction from S.W. and N. E. to E. nearly, and near to that change the magnetic line takes a similar bend, and coincides with the Caucasus, Taurus, Hindoo-Coosh, Himalaya, and Chinese mountains, after which it again tends to the north, and follows the Yablonia chain to Behring's Straits." pp. 295, 296.

We place these quotations in juxtaposition, to show that the tendency of science is to make manifest the simplicity of the works of nature, and thus to bring the construction of the world within the comprehension of the general mind. All these once isolated facts cluster around a general principle. In the language of Mr. Hunt, "The earth in its structure exhibits a singular uniformity; and this, and the trend of its coasts, the direction of mountain chains, the groups of islands, and the cleavage plane of rocks, are evidently the consequence of some all-pervading power; that magnetism has a directing power, is satisfactorily shown by the formation of crystals near a powerful magnet; for then the crystals arrange themselves in magnetic curves from one pole to another, a larger crop of crystals form at the north than at the south pole; and there is a vast preponderance of land in the northern hemisphere." Mr. Saxby has also traced the remarkable coincidence between the line of direction of the mountain ridges and the local curve of equal magnetic variation. Mr. Hopkins, in a report to the British Association, says, —

"All the primary crystalline rocks, and the sedimentary beds in contact, have been more or less cloven in a direction approaching the meridian, and in planes slightly varying from the perpendicular. . . . An action commencing in the most crystalline granite has formed, and still forms, the laminated and polar structure; the granite is thereby transformed into gneiss, the gneiss into mica slate, and the termination of the crystalline structure into clay slate. These great cleavage plains are the cause of the varying structure of the primary rocks, and give rise to the mistaken idea of their being sedimentary rocks subsequently thrown in a vertical direction. . . . Masses of clay in old mines, and most rocks lodged in fissures, acquire a cleavage identical with the containing rock. . . . The cleavage planes must in every instance be developed in the same direction as the internal magnetic current. This current in a semi-fluid mass always causes a westerly deflection of the magnetic needle. Hence the direction of the cleavage planes will be found always to run northeast of the magnetic meridians. Polarity of matter is the key by which we obtain a clue of the causes of the great changes which have taken place on the surface of the earth."

The recent discoveries of Dr. Faraday and other eminent chemists, both of this country and Europe, prove that all matter is the subject of magnetism. We again quote from Mrs. Somerville: —

"Dr. Faraday's brilliant discoveries have changed the received opinions with regard to the magnetic properties of matter. Although all bodies are magnetic, they show that it assumes a totally different form in different substances. For example, if a bar of iron be freely suspended between the poles of an electro-magnet, or very powerful horseshoe magnet, it will be attracted by both poles, and will rest in the direction between them, that is, on the line of force. But if a bar of bismuth be suspended in the same manner, it will be repelled by both poles, and will assume a direction at right angles to that which the iron took; and thus the same force, whether electric or magnetic, produces opposite effects upon these two metals. Substances affected after the manner of iron are magnetic; those affected after the manner of bismuth are said to be *diamagnetic.* All substances come under one or other of these two classes: the diamagnetic are infinitely more abundant than the magnetic; almost all bodies on earth belong to that class. Many of the metals, acids, oils, sugar, starch, animal matter, flame, and all the gases, whether light or heavy, have the diamagnetic property less or more, but oxygen less than any other, and that is the reason why atmospheric air is the most feebly diamagnetic of all substances at its natural temperature; for when very hot it becomes more diamagnetic, and if extremely cold it takes a place among the magnetic class. Importani results with regard to the magnetic state of the globe will undoubtedly be deduced from this new property of matter, and Dr. Faraday's observations on that subject show that he is not without such anticipations." pp. 296, 297.

The bar of iron or of bismuth, the crystal, the leaf of the tree, the oxygen of the air even, places itself in obedience to the line of magnetic force. These lines of force are independent of the matter that is moved by them. The earth, for instance, once considered a huge magnet,* producing and governing the force, appears to be organized and constituted by the flow of the currents established as a distinct force in action upon the matter of which the earth is composed. These lines of action, then, may account for the outlines of the continents, the regularity of the forms of mountains, the parallel ridges of contemporaneous upheaval, the cleavage planes of rocks, the direction of metallic veins, the formation of gems and rubies, and generally, for the similarity of the

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*Mr. Gauss has estimated the total magnetic power of the earth, or one moment of her magnetism, as compared with that of a steel bar of one pound weight, to be in the proportion of 8,464,000,000,000,000,000,000 to 1. *London Quarterly Review.*

geological formation of widely separated countries. There are existing lines of force, and matter according to its nature takes its position in relation to them, either parallel in the same line, or across them at various angles. It is thus that accurately-settled principles, and well-established theories, so far from confusing the mind, display the order and system which prevail in the phenomena of nature. The further the research is carried, the higher the truth which science develops, the more open the path, and the more comprehensible the results; for though it may require the highest mathematical power and the most subtle logic to trace the action of the constructive force, the truth, when obtained, may be comprehended by any mind of ordinary powers.

Mrs. Somerville gives the following account of the agitation of the ocean in consequence of earthquakes and of the tidal wave: —

"When the original impulse is a fracture or eruption of lava in the bed of the deep ocean, two kinds of waves or undulations are produced and propagated simultaneously — one through the bed of the ocean, which is the true earthquake shock, and coincident with this a wave is formed and propagated on the surface of the ocean, which rolls to the shore, and reaches it in time to complete the destruction long after the shock or wave through the solid ocean-bed has arrived and spent itself on the land. The sea rose fifty feet at Lisbon and sixty at Cadiz after the great earthquake; it rose and fell eighteen times at Tangier on the coast of Africa, and fifteen times at Funchal in Maderia. At Kinsale in Ireland, a body of water rushed into the harbor, and the water in Loch Lomond in Scotland rose two feet four inches — so extensive was the oceanic wave. The height to which the surface of the ground is elevated, or the vertical height of the shock-wave, varies from one inch to two or three feet. This earth-wave, on passing under deep water, is imperceptible; but when it comes to soundings, it carries with it to the land a long, flat, aqueous wave; on arriving at the beach, the water drops in arrear from the superior velocity of the shock, so that at that moment the sea seems to recede before the great ocean-wave arrives." p. 155.

"Upon the coasts of Britain and New Brunswick, the tides are high, from the local circumstances of the coast and bottom of the sea; while in the centre of the ocean, where they are due to the action of the sun and moon only, they are remarkably small. . . .

"The tidal wave extends to the bottom of the ocean, and moves uniformly and with great speed in very deep water, variably and

slowly in shallow water; the time of propagation depends on the depth of the water, as well as on the nature and form of the shores. Its velocity varies inversely as the square of the depth — a law which theoretically affords the means of ascertaining the proportionate depth of the sea in different parts; it is one of the great constants of nature, and is to fluids what the pendulum is to solids — a connecting link between time and force." pp. 192, 193.

We join these two quotations to show the similarity, in one respect at least, of the action of earth-agitations on the waters of the ocean, to the diurnal tidal changes of the great deep. The action of the earthquake in raising the water is imperceptible until it approaches soundings; it then impels "a long, flat, aqueous wave." The tidal waves, the diurnal rise and fall of water in the middle of the ocean, "where they are remarkably small," are imperceptible; but they can be traced by the consequent ebb and flow of the surface water on the coast, and in the bays and harbors. In the one case, there appears to be indicated a sharp, spasmodic motion of the ocean's bed; and in the other, is there not intimated a gentler periodic rise and fall of the earth, on which the waters rest?

Professor Lathrop says, (in Silliman's Journal,) —

"The Newtonian theory of the tides has a very imperfect adaptation to a superficial fluid like that of the ocean, of limited depth and broken by continents and islands. It requires for its perfect exemplification a spheroid of revolution fluid to the centre; precisely such a spheroid as that which the geological theory supposes to be enclosed in the crust of the earth. As has been shown, this crust would present no barrier to the attraction of the sun and moon according to the Newtonian theory. It would seem a legitimate conclusion from these premises, that the central fluid is subject to tides, and it must be admitted that there is a constant play of the various parts of the earth's crust in accommodation to the diurnal changes of form of the central fluid."

"Can we," continues Professor Lathrop, "have proceeded thus far in our investigation without being prepared to admit that the oceanic tides, instead of being a direct result of the attraction of the sun and moon, are but a secondary effect, in part at least, a consequence of the tides which prevail in the central fluid? It is quite obvious that the undulations of the earth's crust would produce the regular ebbing and flowing of the sea without reference to the direct attraction of the sun and moon on the waters of the ocean."

It is evident that portions of the earth's crust can rise or fall in relation to other portions; and if so, the attractive force of the sun and moon would as much elevate, and comparatively depress, the crust, as the waters over it. A motion of the earth's crust may therefore be the cause of the tidal flow; and this explanation can be adopted, and still leave the tides under the Newtonian theory of the attraction of the sun and moon.

It may interest our readers to go back to the theory of the tides which somewhat extensively prevailed before the present hypothesis was established. It refers the phenomena to the retarded and accelerated motion of the earth in its annual revolution, and was originated by Galileo. In his "System of the World," this great philosopher "has a very rational discourse on this subject." He supposed that the earth was under the influence of two forces, — the one of revolution around the sun, the other of rotation on its axis, — that there was an acceleration of motion of those parts where the two forces coincided in direction, and a retardation where they acted antagonistically. In the daytime, there is, therefore, an abatement of the annual motion, while in the night time, there is an addition to it. In other words, the diurnal motion in one part of the earth decreases the actual annual motion, and in the other part, — the farthest from the sun, — increases the velocity of revolution. If we transport a vessel of water, any sudden acceleration or retardation will cause the rise of a wave; and the earth carrying the oceans on her bosom, their waters rise in tidal waves from her accelerated and retarded velocity of movement. There is also an accelerated and retarded velocity from the lunar periods, varying the speed of the revolution, as the earth passes to and from the common centre, of the true orbit of the earth and moon; * there is again another acceleration and retardation of the earth's revolution, which is annual, and relates to the elliptical form of

* "From the full moon to the new moon, the earth moves upward from the sun, and from the new to the full, it moves downward towards the sun; from the last to the first quarter, the earth moves forward according to the annual motion, but from the first to the last quarter, contrary to the annual motion. It is manifest, from this hypothesis, that from the last to the first quarter, the menstrual motion of the earth adds something of acceleration to the annual motion; and from the first to the last quarter it abates of the annual motion, and most of all at the full moon." *Transactions Royal Soc.* Kepler believed in "amicable fibres" between the earth and moon, to give an account of this variation of motion.

the orbit. These variations of velocity were supposed by Galileo to give the daily, monthly, and annual inequalities of the surface of the great deep. But he remarked that "his discourse on this subject should be looked upon as an essay of the general hypothesis, which, as to particulars, is to be hereafter adjusted."

To almost every vicissitude of the elements, as well as to the tides, there are two daily maxima and minima; and these have also two maxima and minima of increase in the lunar, and two also in the annual, period. This uniformity denotes some common cause; and it is curious to observe that Galileo's germ of a theory stands confirmed by the epochs of the maxima and minima of meteorological phenomena. If the annual motion be increased and diminished, as the rotary motion coincides with, or is in opposition to it, the maximum of effect would be at the point where conjunction passes into opposition, at the angle or turning point where the two forces vary in direction to a greater degree than they accord. These points of change would not be at noon or midnight, nor in the morning or evening, but at the intermediate stations. Accordingly, we find that 3 P. M. and A. M., and 9 P. M. and A. M., represent the maxima and minima of meteorological phenomena. If we were to suppose that alternate contractions and enlargements of the crust of the globe were possible, we should have a cause, in the conjunction and opposition of the two forces, which would give two daily maxima and minima of extensions, and these, at the very hours when the various maxima and minima of meteorological phenomena take place. Besides, in accordance with this speculation, the earth-change would be the most extensive near the equator; and near the equator the epochs of meteorological change are the most distinctly marked.

In relation to the barometrical epochs we quote from Mrs. Somerville.

"Between the tropics, the barometer attains its greatest height at nine or half-past nine in the morning; it then sinks till four in the afternoon, after which it again rises and attains a second maximum at ten or half-past ten in the evening; it then begins to fall till it reaches a second time its lowest point at four in the morning. The difference in the height is 0·117 of an inch, which gradually decreases north and south. Baron Humboldt mentions

that the diurnal variations of the barometric pressure are so regular between the tropics, that the hour of the day may be inferred from the height of the mercury to within fifteen or sixteen minutes, and that it is undisturbed by storm, tempest, rain, or earthquake, both on the coasts and at altitudes 13,000 feet above them.

"Mr. Pentland has, however, found in the Peru-Bolivian Andes, at elevations between 11,000 and 14,000 feet, the horary oscillations of the barometer as regular, and nearly as extensive, as on the level of the sea in the same latitude." p. 263.

Mrs. Somerville also says, that the fluctuations of the barometer, "produced by the moon, ebb and flow twice during a lunation; and that the annual undulations have their greatest altitudes at the *equinoxes,* and their least at the *solstices.*"

The degree of the electrical force also conforms: "During the twenty-four hours, the electrical state of the atmosphere acquires two maxima and suffers two minima, one at 10 A. M. and 10 P. M., the other at 4 A. M. and 4 P. M." It is well known that the degree of these maxima and minima varies also with the lunar and annual periods. There are also two maxima and minima of the tension of vapor occurring at about the same diurnal epochs, and these fluctuations have again two increases and two diminutions, both in the lunar and annual epochs.

"Between the tropics," says Baron Humboldt, "where the electrical and magnetical phenomena are more fully developed, the hour of the day can be told by the position of the needle as well as by the changes of the barometer. The horizontally suspended needle is found to make, each twenty-four hours, two eastward and two westward deviations from its mean position." We read the following in an article on magnetism in the London Quarterly Review: "This oscillation" (specially noticed in the barometer) "extends to all cases of diurnal fluctuation, and in the case of the tides, the *diurnal* irregularity constitutes one of their most singular, and at present mysterious characters."

Mr. Broun, an expert in magnetism, says, "there is a maximum of westerly declination when the sun and moon are in opposition, and a minimum when they are in conjunction," &c. He clearly shows the connection of magnetism with the phases of the moon. He also says that "the diurnal motion of the north pole of the magnet consists of two or

three loops in winter, the loops becoming gradually unfolded in the spring and autumn months, and disappearing in the summer months." Thus is the connection of magnetism with the annual revolution clearly manifested.*

"The aurora," says Mrs. Somerville, "is decidedly an electrical phenomenon. It generally appears soon after sunset in the form of a luminous arch stretching more or less from east to west, the most elevated point being always in the magnetic meridian of the place of the observer: across the arch, the coruscations are rapid, vivid, and of various colors, darting like lightning to the zenith, and at the same time flitting laterally with incessant velocity. The brightness of the rays varies in an instant: they sometimes surpass the splendor of stars of the first magnitude, and often exhibit colors of admirable transparency, blood-red at the base, emerald-green in the middle, and clear yellow towards their extremity. Sometimes one, and sometimes a quick succession of luminous currents run from one end of the arch or bow to the other, so that the rays rapidly increase in brightness; but it is impossible to say whether the coruscations themselves are actually affected by a horizontal motion of translation, or whether the more vivid light is conveyed from ray to ray. The rays occasionally dart far past the zenith, vanish, suddenly reappear, and, being joined by others from the arch, from a magnificent corona or immense dome of light. The segment of the sky below the arch is quite black, as if formed by dense clouds; yet M. Struve is said to have seen stars in it, consequently the blackness must be from contrast. The lower edge of the arch is evenly defined; its upper margin is fringed by the coruscations, their convergence towards the north, and that of the arch itself, being probably an effect of perspective." p. 291.

It has been ascertained, by observations made at Edinburgh, that the auroral appearances faithfully correspond to the diurnal, lunar, and annual variations. They are at the extreme at 9 o'clock, increasing and diminishing towards that hour;

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* In an old book we find the following experiment recorded, which appears to afford some clue to the position and numbers of the magnetic poles of the earth. The experiment was made by M. de la Hire.

"These experiments gave me the curiosity to make another by touching two semicircles of steel" . . . . "Having joined the ends differently touched, I found that immediately the two half ends ran together and stuck to each other; *and by the steel dust strewed on paper* I observed there were four vortices, one in the middle of each semicircle, and one at each of the places where they were joined; and the two latter were less than the two former. I saw likewise there were four poles, each of which was within a vortex, and that each retained in its semicircle the virtue of the ends of the half rings."

they are the most frequent at the *equinoxes,* and least at the *solstices;* they have a monthly variation of frequency and intensity, being the greatest when the moon is about the end of the first quarter.

Mrs. Somerville gives the following account of magnetic storms : —

" The earth's magnetism is subject to vast unaccountable commotions or storms of immense extent, which occur at irregular intervals, and are of short duration. In 1818, a magnetic storm, shown by a violent agitation of the needle, took place at the same time over forty-seven degrees of longitude, extending through all the countries from Paris to Kasan ; and on the 25th of September, 1841, one of these storms was simultaneously observed at Toronto in North America, at the Cape of Good Hope, Prague in Europe, at Macao in China, and there is reason to believe that it extended to Van Diemen's Land. Similar storms have happened simultaneously in Sicily and at Upsala in Sweden ; others of less extent and shorter periods more frequently occur, and are, like the greater storms, not to be attributed to any known cause." p. 295.

If there were accidents and contingencies in the works of nature, jars and friction in her machinery, "a loose screw or a wheel revolving out of place," it is from magnetic storms, earthquakes, and other apparently spasmodic movements, that we should derive the evidence of them. But the world is not a machine ; it has no defect of action. Every movement is foreseen, provided for, and is of value in the world's economy. The word " catastrophe " should be blotted from the vocabulary of science. It is a confession of ignorance to use a word of this import, as applicable to the works of Him without whom not a sparrow falls to the ground. La Place has said, (Mécanique Céleste,)— " *La course décrite par une simple molecule d'air ou vapeur est réglé d'une manière aussi certaine que les orbites planétaires ; il n'y a de difference entre elles que celle qu'y met notre ignorance.*" *

* Mr. Darwin asks : " How can we conceive of strata thrust in a vertical position without the bowels of the earth gushing out ? " De Beaumont argues : " That when such a fluid " (the central molten mass) " is raised to the top of a mountain 10 or 20,000 feet high, the pressure on the crust with which it is in contact must be more than 1000 atmospheres, or more than 15,000 pounds on each inch area ; and who " he asks, " flatters himself that he knows enough of the interior machinery of volcanoes to be certain that this vast pressure, acting upon a large surface, may not by some derangement of the safety valves, — the volcano vent — produce effects to which we can assign no limits."

Even magnetic storms have their daily, lunar, and annual periodicity, though they have not been clearly elucidated. Earthquakes, too, relate to the equinoctial and solstitial periods, appear related to the age of the moon, and are more frequent at from 9 to 11, A. M. and P. M., than at any other hour of the day. But earth convulsions have been until very lately considered as accidental derangements of safety valves, and their periods have not been observed or classified to any extent.*

We will give only one instance more of the uniformity of meteorological epochs. Professor Loomis makes the following statement: —

"It has been demonstrated, by direct observation, that, at certain localities, — and there is good reason to believe that, in this respect, they are not peculiar, — the wind is subject to a controlling influence which has a period of twenty-four hours, — an influence not of doubtful existence, but powerful — at one time retarding it by nearly one half of its mean velocity, at another, accelerating it by the same quantity, changing not only its intensity but also its direction. The wind is more northerly at three P. M. than at nine A. M. for every month of the year, and the mean force is greater at three P. M. than at nine A. M." †

All these changes have been attributed mainly to diurnal changes of temperature. But temperature does not appear to be itself in accordance with the vicissitudes it is supposed to govern. It is peculiar, having its own special times of increase and diminution. It has but one diurnal maximum, occurring about 1 P. M., and suffers but one minimum, at about 1 A. M., not exactly at noon and midnight; and also one yearly maximum, occurring in the northern hemisphere in July, in the southern in January, not exactly at the solstitial epochs of June and December. And again, there is one annual maximum of the *mean temperature of the whole earth*, which occurs during the sun's northern declination; and one minimum, during its southern declination.

It would seem, from this general view, that the points of the

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* In speaking of the extraordinary fluctuations of the level of the sea, on the southern coast of Cornwall, Mr Edmands says: "It is remarkable that the earth-shocks and extraordinary oscillations of the sea, during the present century, the dates of which are known, (and they are ten in number,) happened near the moon's first quarter, with one exception, and this happened the day before the moon's last quarter."

† Silliman's Journal.

greatest and least temperature locate themselves at the periods of the greatest abatements and accelerations of the annual motion; while other meteorological vicissitudes have their periods of greatest and least intensity at the intermediate or changing epochs, and of course are four in number.* If magnetism relates to the velocity of revolution, and its phases to the acceleration or retardation of the world's motion, do not all the associated vicissitudes bear the same relation? But we forbear. In this paper we seek to establish no special theory of our own, nor do we present ourselves as the opponents of any established hypothesis. We have, however, great reverence for the strong-minded Galileo, and believe it worth inquiry whether his essay of a theory may not be so adjusted in particulars, as to throw much light upon the vicissitudes of the elements; and this, even if we are to continue to trace the action of the tides to the attractive force of the sun and moon.

There is, indeed, a power in science, by its broad generalizations, to give order to the mind and aid to the action of the intellect, by transferring the observation from isolated facts to their life-giving principles; and by the reduction of the number of the present conflicting principles, to carry the mind to the "one only centre," from which all things proceed. We yield to no one in the respect entertained for the professionally scientific; to none, as forming a higher estimate of their acquirements and ability to discover and communicate more of the simple majesty of nature. Every one, however, who has read the records of science, from the time preceding the age of Newton down to the present day, must be struck with the strong contrast presented between the philosophers of old and the modern cultivators of science. There has been a gradual change, so slight perhaps as to be unnoticed in its successive steps, but prominent and visible when we bring together the extremes. Slowly yet regularly there has been a descent from general views to particular considerations, from boldness and comprehensiveness of mind to a painstaking accuracy in the knowledge of facts. We have very eminent mathematicians,

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*There is no lunar maximum and minimum of temperature distinctly traced. If, however, the change exists, the maximum would be soon after the new, and the minimum soon after the full moon. There is a popular notion, that extreme cold for the season often occurs at the full moon.

astronomers, geologists, chemists, naturalists; but where are those who claim the title of philosophers?

The reason is obvious. Ours is a fact-collecting age. Science is divided into departments, and these departments subdivided into sections. Each man selects his own little plat of ground, and becomes an expert in its cultivation. The numbers thus at isolated work are daily increasing, and vast is the aggregate of facts which have been brought together. Observatories are erected in every part of the civilized world; the winds are watched on the land and on the seas; the temperature is recorded from the equator to the farthest attainable position toward the poles; the barometer and needle are transported over the whole surface of the globe, and their fluctuations noted in its deepest caves and mines, and on the summit of its highest mountains. Let any one turn over the reports of the British Association, and he will appreciate the skill, the minute and exact knowledge, displayed in every department.

Great are the advantages of this minute division of labor! Valuable indeed, is the accuracy of detail which has been the result! And this advantage, this value, will become every succeeding year more fully developed by the increasing use of the collected materials. A fact-collecting age has always been followed by a fact-using age. A noble structure will gradually raise itself so high towards the heavens, that there will be spread before the eye a wider sweep of the horizon than ever before was seen by man. We are sanguine and hopeful for science. If the philosophers of other times had had cognizance of the facts now embodied in our annual reports, if the improvements of philosophical apparatus and the almost perfected instruments of observation had been in their hands, they would not have rested in their theories as the ultimate reach of the mind. There is as much zeal and genius in the world now as ever; and there is the vantage-ground of accumulated stores of knowledge and the perfection of the arts, that will insure a rapid advance so soon as there is a right direction of effort. And will not this right direction be induced, somewhat, by the new enterprise of transferring the results of divided research to the public mind in a complete and comprehensive system, such as is now partially displayed in works of the character of the volume now under notice?

Popular works on science, the communication of physical discovery to the newspapers of the day, the appearance of our most distinguished scientific men before the public in the lecture room, the itineration of learned bodies from town to town, in session with open doors, — all show that science appeals to new patrons, and seeks a wider circle of influence, and that the learned in any one department hearken to verdicts other than those pronounced by their peers. This judgment will be favorable in proportion to the simplicity, directness, and comprehensibility of the theory or discovery that is submitted. Thus the attempt to communicate knowledge has its reflex influence. Theory is brought to the test of common sense, to the judgment of those who have no educational bias; and the judgment will be respected. We refer not to the judgment of the ignorant and uneducated. Their opinion on scientific matters is indeed valueless. There is, however, a large and growing class of educated men, with minds quickened by pursuits in life which demand a constant exercise of intellectual power. They are too much engaged in their avocations to become professionally scientific, yet have the time and inclination to know somewhat of this beautiful and wonderful world.* These are the persons who receive the benefits of physical research, and who, by a ready attention and prompt judgment, will react upon the cultivators of science, stimulating them to renewed effort. It is animating and encouraging to the lone student to have his labors thus appreciated, — to know that the sphere of his usefulness is thus enlarged by the increase of the activity of minds engaged in pursuits foreign to his own.

The distinction between those who are professionally engaged in physical research and the general readers of science will ever remain. To be eminent in any department of learning requires an almost exclusive devotion to the subject. But, the degree of learning which gives eminence varies with the general standard of knowledge. As the main body of the

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* Mr. De Quincey, in a late work, speaks of men "not allowing themselves to see that business and the practice of life had given to themselves countervailing advantages; nor discerning that too often the scholar had become dull and comatose over his books, whilst the activity of trade and the strife of practical business set an edge upon their understandings and increased the mobility of their general powers."

army advances, still further in position are the leaders of the band, the distance between man and man being preserved. If the active minds of the community receive an accession of knowledge, so will the men of learning; the diffusion of scientific lore among the people presupposes the greater attainments of the favored few, who have the leisure, education, and talent which fit them for the advanced position.

We rejoice, too, that the minds of our own countrymen are turned towards the theories and discoveries of science. There is a restless activity among us, a love of intellectual excitement, of mental action, which the business of life will not altogether employ. This spare force has now its object, or rather its action, principally in the consideration of political changes, of party politics, and of the social-governmental questions of the day. An exercise of the mind, as a recreation, on a subject foreign to the main pursuit of money-making, is demanded for the moral and intellectual health of the people. Can there be a more health-giving employment of this now worse than wasted energy, than in the comprehension of scientific truth?

There is no subject so attractive, or so full of interest, as the application of the abstractions of physical research to the organization of the world and to the explanation of the vicissitudes of its elements. The works of Nature are a strange and wonderful mingling of the permanent with the apparently fitful — of the exact and methodical with the wandering and eccentric — of the simple and intelligible with the involved and indefinite. Creation seems to unfold a "primary base" around which cluster an interminable host of interlaced vicissitudes. For instance, the base or platform of the celestial movement is the circle; yet in all the planets, the ellipse in varying degrees is engrafted on the perfect curve. The velocity of the motion of the heavenly bodies is in proportion to the distance from the centre; but the position of the centre of revolution varies, hence comes eccentricity of motion, and this in its turn is again varied by occasional perturbation, — a wave-like motion extending through the whole system, rocking every world in sympathetic undulation. Our own earth has a permanent velocity of rotation; its diurnal round has not varied one instant, in all recorded ages; but the inclined angle of the axis throws summer and winter over the

globe, and diffuses over its surface those variations which otherwise would be confined to a narrow zone. The north pole points to the lode star, yet it slowly sweeps around a centre in a cycle of some twenty thousand years; and the position of the magnetic poles follows in unison, while, at the same time, they have their special changes of place. How stable, in one view, the form and fashion of the earth! Yet its surface contracts and expands; the very ground under our feet trembles in convulsion, and in gentler undulations continually changes its level. The conflict of the elements, the storm and tempest, shake the walls of our habitations. Our eyes, accustomed to the mild and equable light of the sun, are dazzled by the lightning which flickers among the clashing of the elements. All is change about us, yet all too is permanent — even the vicissitude manifesting the steadiness of the hand which has a firm grasp upon the elements in their combined and involved motions.

So fixed, certain, and regularly periodic are all things, and yet so mysterious and confused are the lines of force traversing the earth in every direction, and at every angle, that creation seems presented for the exercise of man's intellectual power. It is never to be fully understood, yet every day there is developed in it more and more of the wisdom of God. He who, relying on his own mind or on the intellectual strength of those who preceded him, believes that he has attained to the ultimate; and he who, sunk in apathetic ignorance, considers creation as a mighty maze, without a plan, altogether unintelligible, alike dishonor the Creator; for while His wisdom in its extent is past finding out, He vouchsafes to man those glimpses of truth which are designed to excite the mind to continued search for further developments of the "beautiful and wonderful of the world."

The beautiful and wonderful of the world — a manifestation of the wisdom and power of the Almighty God — His thoughts written out upon the material universe! How can creation fail to interest man, for whom it was called into being? We have a property in the world. It is ours. It is a connecting link between God and man, — common ground, if we may be allowed the bold expression, — something which has flowed out of the heavens, lying between the Creator and the created. If it be used only as it applies to our animal

wants, if it be regarded only on the practical side, it conceals its origin, and is as an opaque body between the eye and the Source of all good. It is the high and holy office of science to give transparency to the globe, so that every ray of light that penetrates its surface may be bent and converged, that all may fasten upon "the one only centre" from which all things proceed.

ART. V. — 1. *A History of the United States of America, from the Discovery of the Continent to the Organization of Government under the Federal Constitution.* By RICHARD HILDRETH. New York: Harper & Brothers. 1849. 3 vols. 8vo.

2. *A History of the United States of America, from the Adoption of the Federal Constitution to the End of the Sixteenth Congress.* By RICHARD HILDRETH. In three Volumes. Vol. I. *Administration of Washington.* New York: Harper & Brothers. 8vo. pp. 704.

IF a plain and well written narrative of public events, mostly in the order of their occurrence, without any attempt to generalize them or to deduce from them the broader lessons of experience, is all that constitutes a good history, then Mr. Hildreth's work deserves its name, and has fair claims to respectful notice. It is easy to see, however, that this is not all, and that history written on such a plan must needs be imperfect and untrustworthy. It must be imperfect, because a large view of the facts, including their connection with each other, and with the causes in which they had their origin and the consequences to which they lead, is in itself a necessary part of the story, without which its other portions teach no valuable lesson, and cannot be fully understood. To keep an exact record of the apparent positions occupied by the heavenly bodies on many successive nights is not the whole duty of the astronomer. He must unravel all the laws on which their seemingly intricate movements depend, and thus enable us, from a detail of the past, to predict the future aspect of the starry heavens at any specified time. The task